

Increasing Students Critical Thinking Skills and Learning Motivation Using Inquiry Mind Map

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Rima Meilita Sari (✉)

Universitas Samudra, Langsa, Indonesia
Universitas Negeri Malang, Malang, Indonesia
rima.sari2121@gmail.com

Sumarmi, I Komang Astina, Dwiyono Hari Utomo
Universitas Negeri Malang, Malang, Indonesia

Ridhwan

STKIP Al-Washliyah, Banda Aceh, Indonesia

Abstract—Critical thinking skills are essential to have to analyze, find relationships, evaluate, solve problems, and make decisions. Promoting the student's critical thinking skills could be done by including critical thinking learning in a learning environment. However, to increase this skill could be achieved, it required the motivation to learn. This study aimed to improve critical thinking skills and students' motivation by implementing inquiry mind maps. The study used a quasi-experimental group with a non-equivalent control-group pretest-posttest. The experimental class used an inquiry mind map, whereas the control class requires that conventional learning. The sample consisted of 206 students from different schools and different genders. Data on critical thinking skills used essay tests. Motivation data learning was taken from instrument motivation toward science learning. Data of critical thinking skills and learning motivation analyzed using ANCOVA. The research findings show that there were differences in the ability to think critically and students' learning motivation using an inquiry mind map tool. The results also examined no difference between school and gender on critical thinking skills and learning motivation. The study results show that the inquiry mind map tool was an impact on increasing critical thinking skills and learning motivation. It was recommended to develop more other learning tools and a learning model to improve critical thinking skills. Some implications were also provided in the article.

Keywords—Inquiry mind map, critical thinking skills, learning motivation

1 Introduction

Critical thinking is a cognitive process that includes skills to analyze, evaluate, infer, and solve problems [1, 2, 3]. During critical thinking, a systematic and organized thinking process is needed to formulate and evaluate findings obtained based on

evidence, assumptions, a logic that can be justified [4]. Having critical thinking skills encourages students to be skillful in dealing with natural and social environments, practically and effectively [5]. Therefore, critical thinking skills are needed for habituation and training through the learning environment [6].

Critical thinking skills have been included in school learning since implementing the 2013 national curriculum in Indonesia. This inclusion is stated in the achievement of learning outcomes that students must have. However, many students still have low critical thinking skills in practice in the field. As found by [7, 8] states that critical thinking skills in school learning are still low. Critical thinking skills in geography learning are also not much different. Research from [4] and [9] states that critical thinking skills in geography learning are deficient due to monotonous learning.

Motivation to learn is an encouragement that moves a person to learn [10]. Learning motivation is an essential factor in learning success. However, the reality in the field, students still have low motivation in geography learning [11, 12]. In other learning subjects, similar things were also found [13, 14].

The importance of critical thinking skills and learning motivation encourages several studies related to learning innovation. One such innovation is a learning model that can accommodate critical thinking skills [15, 16, 17, 18]. The learning model that allows students to practice critical thinking skills has shifted the understanding of traditional education to a more modern direction.

One of the learning models that match the challenges of 21st-century learning is the inquiry model. Inquiry models have been shown to be able to improve high-level thinking skills [19, 20, 21]. This is because inquiry learning emphasizes how to construct science by building experience and knowledge through investigation to activate thinking skills [22]. Besides, inquiry learning also emphasizes the process of problem-solving and active learning processes to increase students' learning motivation [23]. Motivation can be formed through challenging activities of investigation and problem-solving.

In addition to using the inquiry learning model, mind map needs to be used to improve critical thinking skills and learning motivation [21, 24, 25]. A mind map is recommended to complement the inquiry model because its function has been proven able to help students build knowledge through steps to organize several topics related to the problem [26, 27]. Furthermore, a mind map is also able to accommodate students to construct knowledge and activate the brain's work steps. This is because students are free to create color, writing, shape, and size [28].

The use of mind maps can adapt to students' development needs close to the use of technology. One of them is using mind map software. Mind map is based on data, so students can do work projects and make it easier for students to organize projects based on inquiry activities. Therefore, the inquiry mind map tool is expected to improve critical thinking skills and learning motivation. This study also looked at gender factors as a moderator variable. This is based on previous research, which states that gender differences can significantly influence critical thinking skills and learning motivation [21, 29, 30, 31, 32]. Based on the explanation, the research hypothesis that might occur was that there is an influence between using the learning model on the two variables studied. The results and discussion sections provide details about this hypothesis.

2 Literature Review

2.1 Critical thinking skill

Critical thinking skills are among the categories of high-level thinking introduced by John Dewey in 1910 [33, 34]. Critical thinking is a reflective thinking process that focuses on deciding the truth of facts and data [35]. Critical thinking has the characteristics of being able to formulate, analyze, reflect, and evaluate from various perspectives [36]. Therefore, critical thinking is often known as the most responsible thinking.

Building critical thinking skills need steps of rational and systematic thinking. The process of critical thinking requires observation and analysis of similarities and differences and causal relationships continuously [37, 38]. Critical thinking skills are essential for students to quickly identify reliable points and information, provide a focus on better learning, and be sensitive to situations in the field.

2.2 Learning motivation

Learning motivation is a combination of words from "motivation" and "learning." Motivation is a state of self that moves individuals to take action [39]. In the context of learning motivation, motivation is the situation in students that moves them to learn to obtain the expected learning outcomes. There are two influences of learning motivation, namely from the context of learning and socio-cultural influences [40].

Learning motivation influences learning interest, which causes motivation to be an essential factor in determining learning success [15, 41]. Motivation can occur from inside or outside of the students themselves. Internal factors, namely an individual, feel the importance of learning for his development, for example, interest in science and learning orientation. External factors in the form of stimuli from other people and from the surrounding environment that can affect self-motivated people, for example, teacher quality, material weight, learning methods, class conditions, and facilities supporting learning activities.

2.3 Inquiry mind map

The development of the mind map inquiry tool was inspired by mind maps to assist student inquiry learning activities. The inquiry activity is one of the learning steps in the inquiry learning model. The inquiry learning model is a learning model developed by Richard Suchman [42]. This model is under the constructivist learning theory. The inquiry model has the characteristics of student-centered learning, the learning process is done by question and answer, and the teacher as a facilitator of learning activities. The contribution of the inquiry learning model to improve high-level thinking skills is in the syntax of inquiry [21].

A mind map is a tool used to organize ideas, concepts, and information and make thinking more effective and systematic [43]. The mind map model aims to activate the brain's work steps through variations in color, shape, and writing [43]. The mind map gives students the freedom to search for knowledge and learning experiences inde-

pendently [44]. Therefore, this model is suitable for constructing knowledge and is recommended to be developed [45, 46].

Mind Maple software is a learning media that is used to present findings in a more structured form. Mind Maple is software that can be used on computers and tablets that are easily accessed by students. Mind maple has a more positive impact on learning outcomes than using other presentation media such as PowerPoint [47].

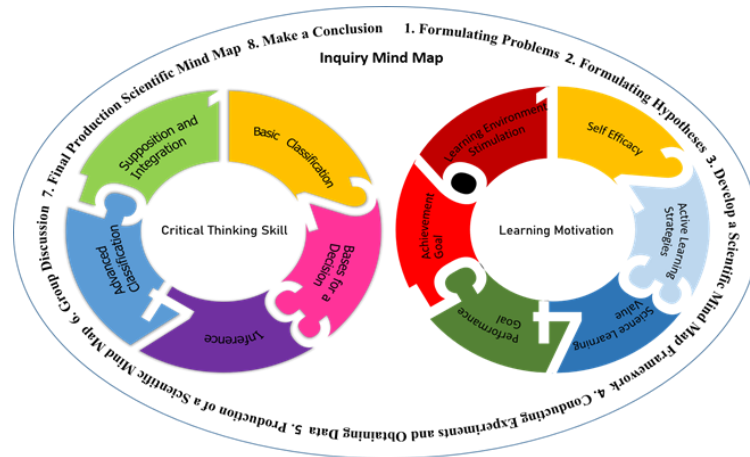


Fig. 1. Inquiry Mind Map

2.4 Research objective

Based on previous research, no studies that explicitly examined the effect of inquiry learning assisted with the inquiry mind map tool on critical thinking skills and integrated learning motivation in terms of gender differences. Therefore, the purpose of this study was to identify:

1. Differences in critical thinking skills between students given treatment using inquiry learning assisted with inquiry mind map tool and those who taught using conventional learning
2. Differences in learning motivation between students given treatment using inquiry learning model integrated with a mind map and those who taught using conventional learning
3. Differences in critical thinking skills between male and female students
4. Differences in learning motivation between male and female students
5. Differences in critical thinking skills influenced by the interaction of learning tool and gender
6. Differences in learning motivation influenced by learning tool and gender interaction

The results of the study were expected to contribute to providing a choice of innovative models to develop critical thinking skills and student learning motivation following the demands of the 21st-century industrial revolution.

3 Methodology

3.1 Research design

The study produced quantitative data from the quasi-experimental research design with the non-equivalent pretest-posttest control group using 2x2 factorial. There were two independent variables and two dependent variables. The independent variable was the learning model (inquiry model assisted by mind map and conventional learning) and gender (male and female). The dependent variable was critical thinking skills and learning motivation. The description of experimental research design can be seen in Table 1 as follows.

Table 1. Design of Experimental Research

Pretest	Group	Post-test
O ₁	X ₁ Y ₁	O ₂
O ₃	X ₁ Y ₂	O ₄
O ₅	X ₂ Y ₁	O ₆
O ₇	X ₂ Y ₂	O ₈

Notes:

- O_{1,3,5,7} = pretest (critical thinking skills and learning motivation)
- O_{2,4,6,8} = post-test (critical thinking skills and learning motivation)
- X₁ = inquiry mind map tool at students' learning activities
- X₂ = conventional learning
- Y₁ = Male
- Y₂ = Female

The first step of the research was to determine the control group and the experimental group. The second step was students working on the pretest of critical thinking skills and learning motivation. The third step was the experimental group's treatment using an inquiry learning assisted inquiry mind map tool while the control group used conventional learning. The final step of the research was that students work on post-test critical thinking skills and learning motivation.

3.2 Research population and sample

This study's population was all high school students of class XI of 13 high schools in the city of Banjarmasin, Indonesia. Schools selected as research subjects represent the geographical part of the city of Banjarmasin. High School A is located in the north of Banjarmasin, High School B represents the central part of Banjarmasin, and High School C is in the southern part of Banjarmasin. The total sample study involved 206 different gender students. The study involved 115 male students and 91 female students. The sample selection used a multi-stage sampling technique by selecting school

samples and determining the selected schools' experimental and control groups. Determination of the experimental group and the control of the selected school was based on the final school exam scores that were almost close together.

3.3 Research setting

This research was conducted for 12 meetings over 3 months, starting from October to December 2018. The research took the material in accordance with the ongoing material in the class, namely "analyzing national food security, industrial materials supply, and the potential for new and renewable energy in Indonesia." The material was held for 90 minutes for each meeting.

3.4 Research implementation

The inquiry mind map tool's implementation was conducted in 3 classes in each different school as the experimental group. The same thing was applied to the control group taught with conventional learning. The learning step uses the inquiry mind map tool to use inquiry activity learning, there are 8 steps of learning, namely:

- 1) Problem solving
- 2) Formulation of hypotheses
- 3) Designing an ideal framework on the inquiry mind map tool
- 4) Experimenting to obtain data
- 5) Creating a mind map
- 6) Group discussion
- 7) Final production of the inquiry mind map
- 8) Conclusions.

The experimental group was equipped with a student worksheet that contained instructions for implementing learning and investigative instructions. Student worksheets were adjusted to the inquiry learning model by modifying the inquiry mind map as a tool created to facilitate the organization of ideas and findings. Students in the experimental group were taught to conduct experiments and investigations on the problems presented. The problems presented were given by the teacher following the topic of discussion at each meeting.

The stages of learning in the experimental group included: the teacher provided a general description of the problem. Next, the teacher divided students into 8 heterogeneous groups and shared assignments. Meanwhile, students formulated problems and started predicting the answer. Students began to formulate solutions and arranged mind map frameworks to organize investigative activities in the next stage. After that, students carried out investigative and experimental activities to find solutions and collected data and facts from various sources to test hypotheses. Furthermore, students were re-assembled to reflect on quick answers. At this stage, students were given the freedom to present the results to other groups. In contrast, other groups review the strengths and weaknesses of the presenter group's investigation results.

Weaknesses in the interim review results are material to conduct further investigations and experiments to prove the truth. The results of further investigations were described in a mind map, which consisted of conclusions of the problem, data, and facts found, the investigation process, solutions, alternative solutions, strengths, and weaknesses of the solutions provided. The results of the mind map were then displayed and discussed again with other groups. This stage aimed to obtain feedback and suggestions from other groups, allowing students to find other alternative solutions and reevaluate the correctness of data and facts found. The control group used the same duration and essential competencies as the experimental group. The learning method used in the control group was discussion and question and answer.

3.5 Instrument

Instruments were given to 206 students before treatment (pretest) and after treatment (posttest). The instrument consisted of 2, namely the instrument of critical thinking skills and learning motivation. Assessing students' critical thinking skills used an instrument of critical thinking ability [4]. The instrument is in the form of an essay test. The reason for choosing an essay test in critical thinking skills was that this type of test was most effective in assessing complex learning outcomes and required consideration [48]. The essay test was also chosen because it was considered most suitable to be implemented in Indonesia [21]. The test was adjusted to the fundamental competencies "analyzing National Food Security, Industrial Material Supply, and Potential for New and Renewable Energy in Indonesia".

To measure learning motivation, we use instrument Student Motivation Toward Science Learning (SMTSL) by [49]. The reason for using this learning motivation instrument was that active learning was influenced by stimulation from the same environment as the application of treatment to each group. Instrument SMTSL consisted of six assessment indicators, namely:

- 1) Self-efficacy
- 2) Active learning strategy
- 3) Science learning value
- 4) Performance goals
- 5) Achievement goals
- 6) Learning environment stimulation [49]

The instrument was a questionnaire with 5 measuring scales using a Likert scale from answers 1 (strongly disagree) to 5 (strongly agree). The instrument had been validated in content and construct. The Cronbach alpha calculation of six indicators was 0.870. The Pearson correlation calculation number ranged from 0.09 - 0.51.

3.6 Data collection and data analysis

Quantitative data were collected based on the pre-test and post-test results in the experimental and control groups who took the test of critical thinking skills and learn-

ing motivation. Data were analyzed using covariance analysis (ANCOVA), normality test, and homogeneity with SPSS 23 for windows. Before starting the covariance (ANCOVA), the normality test was carried out using the Kolmogorov - Smirnov One Sample. Then the data were tested for homogeneity using Leven's test.

4 Result

This study aimed to answer the research questions that had been formulated. Before carrying out the ANCOVA test, a normality and homogeneity test was carried out to determine which data was normally distributed and homogeneous. The $p\text{-value} > \alpha$ ($\alpha = 0.05$) in the normality test using the Kolmogorov Smirnov test and $p\text{-value} > \alpha$ ($\alpha = 0.05$) in the homogeneity test using the Levene's test. Test for the normality of critical thinking skills showed a value of $0.08 > \alpha$, which meant that data was normally distributed. The homogeneity test results showed $0.09 > \alpha$, which meant that students' critical thinking skills were homogeneous. Furthermore, the normality test results of learning motivation showed a value of $0.200 > \alpha$, which meant the data was normally distributed. In contrast, the homogeneity value showed $0.070 > \alpha$, which meant the data was homogeneous. The results of ANOVA analysis on the variables of critical thinking skills and learning motivation are summarized in Table 3.

Table 2. ANCOVA Test on Critical Thinking Skills and Learning Motivation

	Source	Df	Means Square	F	Sig	η^2
Critical Thinking After Implementation*	Corrected Model	3	2743.340	17.135	.000	.203
	Intercept	1	1210551.077	7561.287	.000	.974
	Gender	1	1.087	.007	.934	.000
	Model	1	8222.461	51.359	.000	.203
	Gender*Model	1	62.366	.390	.533	.002
	Error	202	160.099			
	Total	206				
	Corrected Total	205				
Learning Motivation After Implementation**	Corrected Model	3	208.155	3.780	.010	.054
	Intercept	1	4122575.350	76639.474	.000	.997
	Gender	1	177.125	3.293	.071	.016
	Model	1	307.904	5.709	.018	.027
	Gender*Model	1	176.203	3.276	.072	.016
	Error	202				
	Total	206				
	Corrected Total	205				

Note:

*R Squared = .203 (adjusted R Squared = .191)

**R Squared = .054 (Adjusted R Squared = .040)

Based on Table 2, it is known that there were differences in critical thinking skills between experimental group students and control group students. This was indicated by the effect test value $F = 51,359$ with a significance level of $0,000$ ($p > 0.05$). The model provided a large effective contribution to critical thinking skills with a value of

$\eta^2 = 0.203$. The covariance test results also showed no difference in critical thinking skills between male and female students with a value of $F = 0.007$ with a significance level of 0.934 ($p > 0.05$). Table 3 also shows that there was no difference in critical thinking skills as a result of the interaction between learning models and gender with a value of $F = 0.390$ with a significance level of 0.533 ($p > 0.05$).

Furthermore, the ANOVA test results on learning motivation variables showed differences in learning motivation between the experimental group students and the controls with a value of $F = 5.709$ with a significance level of 0.018 ($p > 0.05$). The learning model provided a significant contribution to increasing learning motivation with a value of $\eta^2 = 0.027$. Meanwhile, from the results, it can be seen that there was no influence between male and female students in learning motivation with a value of $F = 3.293$ by a significance level of 0.071 ($p > 0.05$). Likewise, the learning motivation was based on the results of the interaction between the model and gender differences which showed that there was no significant difference with the value of $F = 3.276$ and the significance level of 0.072 ($p > 0.05$).

5 Discussion

The results showed that critical thinking skills and learning motivation increased after treatment in the experimental class using learning activities with an inquiry mind map tool. This proved that learning activities in using inquiry mind map tools were far better than the conventional class. This result was supported by previous research that mind map can complement the implementation of the inquiry activities [50].

Using learning activities with an inquiry mind map tool can improve critical thinking skills supported by previous research. Research from [51] stated that the inquiry model supports high-level thinking skills through formulating problems, building knowledge through investigation, and solving problems. This process involved students thinking actively during the learning activities [52, 53, 54]. This process makes students trained to seek their knowledge, so students are accustomed to assessing the validity of the knowledge gained. Critical thinking skills were also supported by the findings of [55] which explained that if students search for knowledge by themselves, it could improve their understanding because, during the process of finding knowledge, their critical thinking skills will increase.

In the inquiry process, students build knowledge through a problem-solving process. This process has an output in the form of solutions that can improve thinking critically, creatively, decision making, and process information [56, 57]. This was reinforced with the help of inquiry mind map tools during learning activities. This tool made it easy for students to organize ideas and activate brainwork so that findings during inquiry activities can be organized neatly [5, 21, 50].

The inquiry mind map tool can give students freedom during learning activities because it supported inquiry activities. This finding was supported by [21], who explained that the mind map could facilitate each step of inquiry while integrating it so students can organize and understand information systematically and effectively.

This ability started from basic knowledge to more complex. This made mind map capable of supporting critical thinking skills components [58].

Inquiry mind map tools can give students an unexpected way of thinking. The ease provided by the mind map can provide an overview of information by combining images, words, numbers, and colors. This technique activates the brain's working steps in thinking and gives a big picture and details of small drawings at the same time, so that it makes easier for students to construct knowledge and improve skills for thinking scientifically, creatively, and innovatively [27].

In learning motivation, the inquiry activities give students the freedom to seek their knowledge. The freedom given by the teacher is always related to problem-solving. Freedom during learning makes students feel happy and have high motivation while participating in learning activities [59]. Freedom of learning creates intrinsic motivation that leads to successful learning [60]. [61] states that the success of learning outcomes is determined if students have high learning motivation.

Grouping students in inquiry learning helps achieve learning goals because they do not feel alone in learning activities [23]. The similarity of activities spurs students to continue to solve problems together. The existence of discussions between individuals in groups and outside groups allows students to enrich information to prefer learning. The results of a similar study were also revealed by [62] which states that inquiry-based activities have an impact on increasing positive attitudes during learning because students have the freedom to choose projects that are in demand and able to provide opportunities for students to assess their abilities.

Using inquiry mind map tools at learning activities gave a positive result on increasing the learning motivation of the experimental class students. The investigation process using mind map makes it easy for students to understand and remember because it uses keywords that are determined by students. Furthermore, learning using mind map assistance makes it easier for students to gather information during the learning process so that it is more attractive [63]. The results of this study are also supported by research from [44] and [55] which stated that the mind map model could facilitate the process of identifying information to be better, facilitate the process of combining information, and memory, and increase students' interest in learning.

The ANCOVA test results of gender's influence of gender on critical thinking skills showed no differences in critical thinking skills between men and women. This is because the learning process experienced by male and female students is the same or without differences. Some studies also support findings stating that there is no effect of gender differences on critical thinking skills [29, 30]. However, some previous findings are known to be different from the results of this study. [32] stated that female students have critical thinking skills better than male students do. [1] stated that male students tend to have better critical thinking skills than female students do.

The results of the study also showed that there was no difference in motivation for learning in terms of gender differences. This is because male and female students experience the same treatment in the experimental and control groups. In the experimental group, inquiry activity was carried out by dividing students into eight groups with a heterogeneous division (regardless of differences in learning and gender values). Inquiry learning using heterogeneous groups is far more effective for construct-

ing student knowledge because each student has different knowledge and experience [64]. The study results are supported by previous findings that there is no difference in student learning motivation in terms of gender differences [65]. However, [66] stated that the research results he conducted are different, which shows that female students have higher learning motivation than male students. Similar results were also shown by [31], which stated that female students' learning motivation was far greater than male students. Other research results also show no interaction between models and gender concurrently towards critical thinking skills and learning motivation. This is caused by critical thinking skills and learning motivation, which have significant differences when viewed from model treatment differences. However, there were no significant differences found when viewed by gender differences. It can be concluded that the inquiry mind map can improve critical thinking skills and learning motivation in all students regardless of gender differences.

6 Conclusion

The results showed that:

- 1) There were differences in critical thinking skills between the experimental group students who were using inquiry mind map tools for learning activities and control group students treated using conventional learning
- 2) There were differences in the learning motivation of the experimental group and the control group
- 3) There was no difference in critical thinking skills between male and female students
- 4) There was no difference in learning motivation between male and female students
- 5) There was no difference in Critical thinking skills influenced by the interaction of learning models and gender
- 6) There was no difference in learning motivation influenced by the interaction of learning models and gender

The results also show that using an inquiry mind map tool for learning activities can improve critical thinking skills. Student learning motivation was better than students who had not used it. This study was limited to two influential variables. Further research is suggested to link more variables that influence each other's critical thinking skills and learning motivation.

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9 Authors

Rima Meilita Sari is a lecturer at the Geography Education Program, Faculty of Teacher Training and Education, Universitas Samudra, Langsa, Indonesia.

Sumarmi is a Professor, Researcher, and senior lecturer at the Geography Education Program, Faculty of Social Science, Universitas Negeri Malang, Jl. Semarang No. 5, Malang, Jawa Timur, Indonesia.

I Komang Astina is a senior lecturer at the Geography Education Program, Faculty of Social Science, Universitas Negeri Malang, Jl. Semarang No. 5, Malang, Jawa Timur, Indonesia.

Dwiyono Hari Utomo is a senior lecturer at the Geography Education Program, Faculty of Social Science, Universitas Negeri Malang, Jl. Semarang No. 5, Malang, Jawa Timur, Indonesia.

Ridhwan is a lecturer at the Geography Educational Program, STKIP Al-Washliyah, Banda Aceh, Indonesia

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